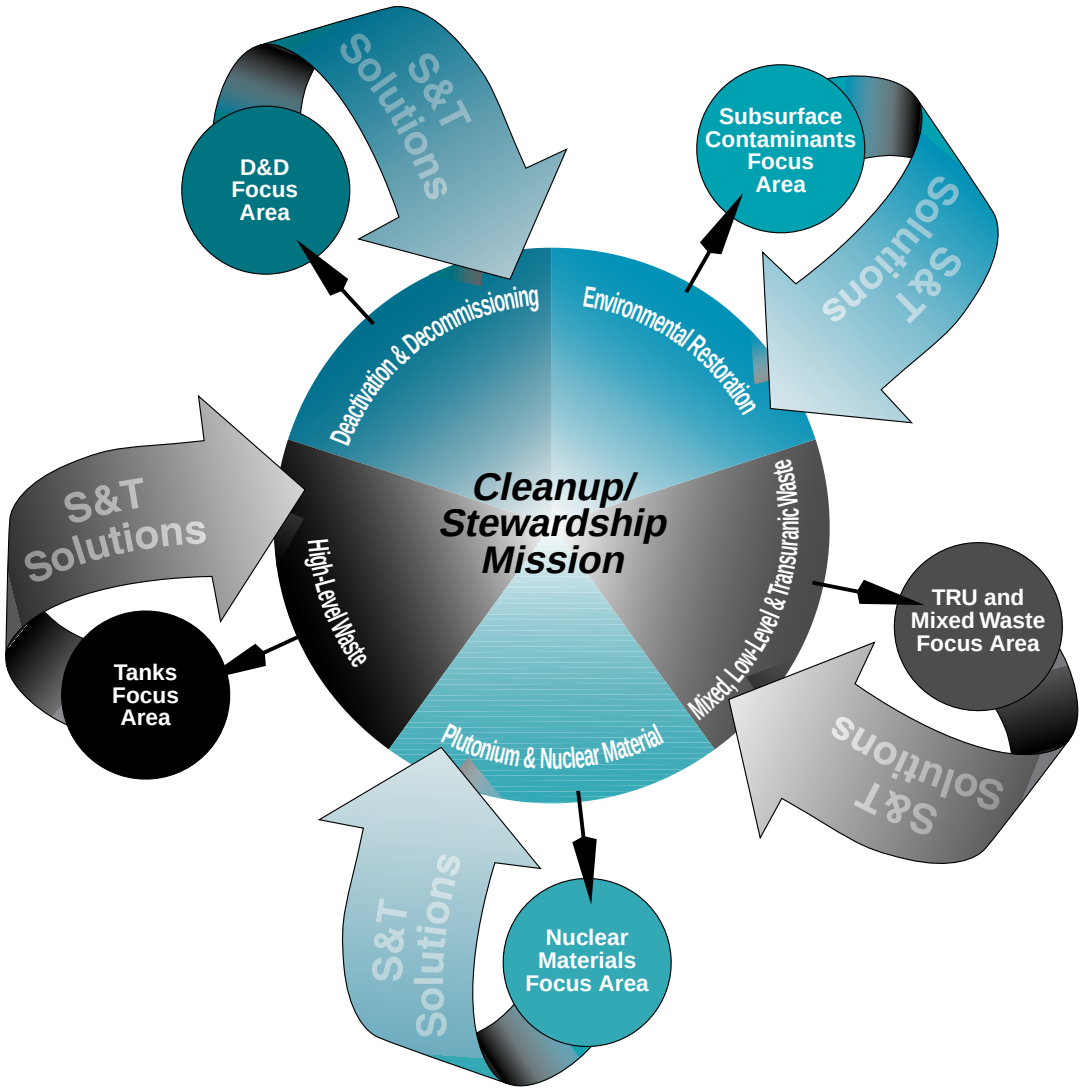
DOE/EM-0570

# Office of Science and Technology

## Annual Report

# FY 2000




U.S. Department of Energy
Office of Environmental Management

The Office of Science and Technology (OST) is part of the U.S. Department of Energy (DOE) Office of Environmental Management (EM). OST manages a national program to identify and develop innovative technologies that help EM meet its cleanup goals. OST conducts basic and applied research, technology development and demonstrations, and technical assistance to solve EM cleanup problems and reduce the cleanup costs at DOE sites nationwide. Technology solutions deployed with OST's support are detecting, characterizing, and remediating contamination; managing waste; improving worker safety; reducing risk; and enabling cleanup to be completed.

OST is aligned with EM cleanup program needs identified by customers, users, regulators, and stakeholders. Through technical assistance and multisite deployment programs, OST is continuously increasing the number and quality of innovative technologies being applied to EM cleanup problems. OST focuses on providing environmental research results and cleanup technologies and systems that meet EM's high-priority science and technology needs for environmental cleanup and long-term stewardship at DOE sites nationwide.

OST addresses site needs through a focus area–centered approach, which streamlines technology management activities into one field-based team for each major problem area. The focus areas integrate the activities of other programs whose products cut across problem areas to support EM: robotics, separations, characterization and monitoring, and liaison to industry and universities.

# Contents


Science and Technology: Enabling DOE EM to Meet Its Aggressive Schedule . . . . . 1

Key FY 2000 Accomplishments . . . . . 2

OST Focuses Science and Technology on Our Customers' Highest-Priority Needs . . . . . 4

- Deactivation and Decommissioning Focus Area . . . . . 4
- Subsurface Contaminants Focus Area . . . . . 4
- Nuclear Materials Focus Area . . . . . 6
- Tanks Focus Area . . . . . 6
- Transuranic and Mixed Waste Focus Area . . . . . 8

Basic and Applied Research Provides Important Knowledge and Enhances Capabilities . . . . . 10

Research and Development Laboratory Management Stewardship . . . . . 11

Innovative Technical Solutions Are Achieving Multiple Deployments and Redefining Baselines . . . . . 12

EM's Investments in Science and Technology Are Paying Off in Life-Cycle Cost Reductions . . . . . 14

EM Is Preparing for the Age after Remediation . . . . . 16

Innovative Technologies: Safety Included . . . . . 17

Responsible Investments in EM Problem Areas . . . . . 18

# Science and Technology: Enabling DOE EM to Meet Its Aggressive Schedule

Fiscal Year 2000 was an excellent year for EM's Office of Science and Technology. We take pride in knowing that our technologies are making a difference where it counts—in the field. In fact, it is clear that OST-developed and -demonstrated technologies are playing an ever increasing role at DOE sites, where they are becoming the baseline technologies for addressing the toughest cleanup problems.

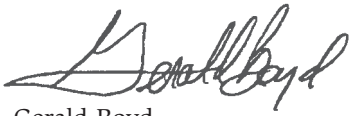
In FY 2000 we again exceeded the targets set for technical solutions demonstrated and deployed. We accepted leadership roles on several important departmental initiatives while still conducting early-stage R&D and steadily deploying technologies that will accelerate cleanup—or simply enable it—and avoid the increased costs of delayed cleanup schedules. Our accomplishments were numerous, and many are highlighted in this annual report.

- The OST Technology Assistance Team concept was proven at Paducah and Pantex, where teams addressed critical site needs and earned the praise of the Secretary of Energy.
- OST technologies revolutionized the approach for decontamination and dismantlement of plutonium-contaminated gloveboxes at Rocky Flats, enabling drastic reductions in projected waste volume while improving worker safety and efficiency.
- We increased the scope of one of our focus areas, now the Transuranic and Mixed Waste Focus Area, effectively connecting us to DOE's national transuranic waste program and helping ensure we are serving its technology needs.
- OST provided technical leadership to the Secretary's Blue Ribbon Panel and accepted the challenge of evaluating technology alternatives to waste incineration.
- Our Environmental Management Science Program delivered a comprehensive and relevant reference book providing important information on the characterization and predictive capabilities of emerging vadose zone technologies.
- The tank waste processing improvements we are developing will produce enormous savings by reducing the volume of high-level waste requiring immobilization and storage.

We are not resting on our successes. There is more to be done. Our customers throughout EM acknowledge a strong need for continued investment in science and technology integrated into the EM program because there are near-term challenges to meet for sites targeted for cleanup by 2006. Many of the sites where cleanup will continue after 2006 have waste streams and contamination presenting some of EM's toughest problems—ones for which there are no currently viable solutions. We will continue to focus on DOE's highest-priority environmental cleanup needs and maintain our steadfast commitment to close partnerships between problem owners and problem solvers.

We understand the most difficult challenges are ahead of us. But as we look to the future, OST will continue to provide technology leadership to EM. We will lead the development and testing of technical alternatives to incineration, and we will do our part to ensure that technologies we develop incorporate safety-in-design concepts. And I am personally committed to our leadership in interagency efforts focused on solving common problems, such as DNAPLs.

I am pleased to present this overview of recent program accomplishments and near-term initiatives because it shows that innovative technical solutions developed or discovered and deployed under OST sponsorship are making the cleanup of DOE legacy facilities faster, cheaper, and safer. I encourage you to read how the solutions we have championed are positioning EM for success in meeting its environmental cleanup goals. We welcome this opportunity to show how the Office of Science and Technology is focused—and making progress—on these goals, maximizing the value of DOE investments in science and technology for environmental cleanup.



Gerald Boyd
Deputy Assistant Secretary
Office of Science and Technology

# Technology Needs Already Addressed

- ☑ Alternatives to Pump and Treat
- ☑ Tank Waste Retrieval
- ☑ Reactor Safe Storage
- ☑ Underground Barriers
- ☑ Mixed Waste Characterization

## Vadoze Zone Characterization

Published comprehensive reference on technology solutions

## Contaminated Groundwater Plumes

Installed multiple in situ remediation systems

## Glovebox Disposition

Enhanced efficiency and worker safety at Rocky Flats

## Integrated DNAPL Consortium

Demonstrated and deployed three effective OST technologies

## Technical Assistance Teams

Addressed critical groundwater cleanup issues at Paducah and Pantex

## Tank Corrosion Monitoring

Reduced worker exposure and labor costs at Hanford

## Safer Repackaging and Transfer Systems

Deployed vacuum transfer systems for uranium material at Fernald

# Key FY2000 Accomplishments

## Plutonium Material Shipment

Helped meet milestones with highly accurate measurement technologies

## Alternatives to Incineration

Provided technical leadership for Secretary's Blue Ribbon Panel

## Long-Term Stewardship

Analyzed data and prepared reports to establish baselines for scope, cost, and schedule

## Waste Separation

Developed innovative detector to segregate TRU from non-TRU waste

## Focus for the Future

- ❑ Material processing plant deactivation/cleanup
- ❑ High-level waste immobilization
- ❑ Nuclear materials stabilization
- ❑ Spent nuclear fuel disposal
- ❑ In situ metal treatment/immobilization
- ❑ Long-term monitoring for waste cells
- ❑ Alternatives to incineration
- ❑ Transuranic waste to Waste Isolation Pilot Plant

# OST Focuses Science and Technology on Our Customers' Highest-Priority Needs

The **Deactivation and Decommissioning Focus Area** (DDFA) addresses the D&D of some 20,000 contaminated facilities in the DOE complex, with a D&D "mortgage" estimated in excess of $39 billion. DDFA's goal is to reduce that mortgage 25% for pre–FY 2006 costs and 50% for post–FY 2006 costs, while reducing risks to the workers, public, and environment. In FY 2000, 29 DDFA-sponsored technologies were demonstrated, and more than 40 were deployed in actual site D&D projects. DDFA is working to meet the demand for robotics and other remote strategies to automate D&D processes, making them more efficient and cost-effective and creating safe conditions for D&D workers.

More than 900 plutonium-contaminated gloveboxes must be removed, cut up, and disposed of to meet the accelerated Rocky Flats site closure goal of FY 2006. The baseline method—workers in cumbersome protective gear using hand tools—couldn't have met schedule or budget requirements. In the last three years, DDFA projects have delivered several innovative technologies that revolutionize this process:

- The Decommissioning In-Situ Plutonium Inventory Monitor delivers more accurate and sensitive assays prior to size reduction, enabling better planning, enhancing safety, and minimizing waste generation.
- The Inner Tent Chamber enables faster cutting with lightweight power tools and remote-control tools like plasma cutters, while protecting workers and the environment from airborne contamination.
- Using the Standard Waste Box (SWB) requires less size-reduction, resulting in fewer containers and lower transportation costs.
- The Mobile SWB Counter, constructed, calibrated, and validated by Los Alamos National Laboratory, measures radiation levels for entire containers of mixed waste types. Reduced waste segregation and handling not only enhance worker safety but dramatically cut paperwork and administration costs.

*The Inner Tent Chamber is enhancing safety and ergonomics for cleanup workers at Rocky Flats.*

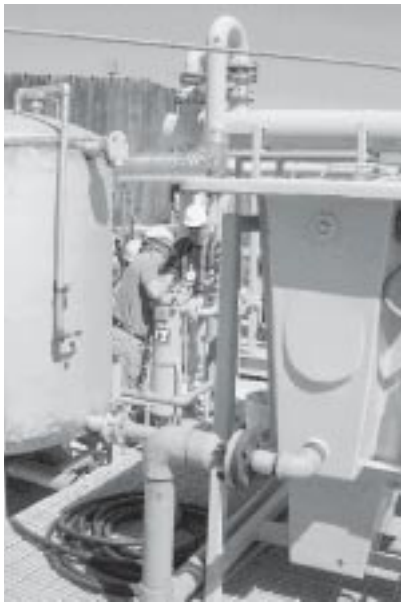
The **Subsurface Contaminants Focus Area** (SCFA) addresses an estimated 1.7 trillion gallons of contaminated groundwater, 75 million cubic meters of contaminated soil, and 3 million cubic meters of buried waste. In FY 2000, SCFA invested more than $34 million on 60 end user–approved projects to identify, contain, or remove subsurface contamination and to validate the long-term effectiveness of these solutions. Twenty are Accelerated Site Technology Deployment (ASTD) projects, equally cost-shared with the field end user. End users deployed 31 SCFA-developed technologies, and 14 technologies were demonstrated. SCFA technical assistance teams responded to end user requests for help in selecting solutions for remediation challenges, troubleshooting technology installations, and tailoring solutions to specific applications for optimal performance (see box opposite).

Remediating dense, nonaqueous-phase liquids (DNAPLs) is one of the most difficult environmental challenges faced by federal agencies and private industry. OST has taken a leadership role in the Interagency DNAPL Consortium (IDC), a unique collaboration with the Department of Defense, the Environmental Protection Agency, the National Aeronautics and

Space Administration, and Florida State University to leverage resources by working together to solve a common problem. The IDC selected three SCFA technologies, developed with national laboratory partners, for side-by-side demonstration of performance and cost. These promising technologies—Dynamic Underground Stripping, Six-Phase Soil Heating, and In Situ Chemical Oxidation—remove DNAPL contamination in years rather than decades. In January 2000, nearly 300 technology end users, regulators, lawyers, and other stakeholders toured the demonstration site at Cape Canaveral Air Station in Florida, hosted by the IDC, to learn more about the benefits of these three technologies and issues associated with their deployment.

SCFA's Reactive Barrier Technologies have been deployed at seven sites a total of nine times to help meet DOE's cleanup goals. These technologies capture and treat contaminant plumes underground using natural hydrologic flow, significantly reducing the cost and risk associated with remediation.

Many contaminated groundwater plumes are dispersed over large areas and located hundreds of feet below ground. Effective treatment requires in situ manipulation of natural processes to change the mobility or form of the contaminants. In Situ Redox Manipulation creates a permeable treatment zone where redox-sensitive contaminants in waste plumes are immobilized or destroyed. Human exposure to potentially hazardous materials is greatly diminished because neither contaminated groundwater nor matrix material is brought above ground.



*Dynamic Underground Stripping is removing DNAPLs at the Savannah River Site.*

## SCFA Lead Lab Exemplifies OST's Technical Assistance to Address Critical Site Needs

OST Technology Assistance Teams—groups of the brightest scientists and engineers from universities, laboratories, and the private sector—are available to EM sites to provide technical assistance for urgent on-site consultation targeting specific high-priority EM needs. In FY 2000, the SCFA Lead Laboratory—the Savannah River Technology Center (SRTC)—served as what the Secretary of Energy called a "model" of technical assistance. SRTC and its partner labs have responded to numerous requests for technical assistance from the sites and the SCFA Lead Office, from brief consultations to teams of technical experts spending a week or more at a site. Two intense efforts took place this year.

At the Paducah (Kentucky) Gaseous Diffusion Plant, a team recommended ways to accelerate cleanup of on- and off-site groundwater. The team worked with staff of the Innovative Treatment Remediation Demonstration Program to identify about 30 technologies that could enhance remediation and reduce costs, including feasibility testing of complementary in situ innovative technologies for the dissolved plume of trichloroethylene (TCE) and technetium. Technical assistance involved the feasibility and design of an innovative permeable treatment wall to intercept the two contaminants. The team recommended additional characterization to improve remedial design and increased performance verification. Assistance will continue through design, installation, and verification phases.

In March 2000, a technical assistance team responded to the discovery of TCE in the Ogallala Aquifer beneath the Pantex weapons facility in Texas. The SCFA Lead Lab staffed the technical team, which recommended several groundwater characterization improvements and identified innovative remediation and monitoring technologies. The team recommended establishing a partnership between DOE and regional organizations to develop an approach to protecting the Ogallala Aquifer. A follow-up team helped Pantex review sitewide groundwater data, with a specific focus on groundwater contamination in the southeast area of the plant.

The **Nuclear Material Focus Area** (NMFA) conducts a program to research and develop technologies to support the safe management and effective stabilization of the thousands of metric tons of nuclear materials under EM's purview. NMFA is supporting closure sites and facilities by improving plutonium-stabilization and materials processing and developing technologies for packaging, transportation, and long-term storage.

Thousands of kilograms of plutonium materials at DOE sites must be stabilized and repackaged for shipment to long-term storage, but the inadequacies of current moisture measurement technology are jeopardizing site closure milestones and stakeholder agreements. Supercritical Fluid Extraction Moisture Measurement, developed in collaboration with the Hanford Site, provides more accurate results and avoids time-consuming and costly repackaging.

*SFE Moisture Measurement, already deployed at Hanford's Plutonium Finishing Plant, may also help Rocky Flats meet closure milestones.*

The removal of uranium material from Fernald is crucial for timely decontamination and demolition of storage facilities. Site remediation activities have reduced process capabilities, and there are no systems in place to prepare these materials for shipment. NMFA is working to deploy automated repackaging and vacuum transfer systems to address stakeholder concerns and meet regulatory agreements.

The **Tanks Focus Area** (TFA) delivers technical solutions for radioactive tank waste remediation, addressing the needs of five EM sites storing 92 million gallons of waste in 280 tanks. In FY 2000, TFA achieved 24 deployments (including five technical solutions from crosscutting programs) and completed eight demonstrations. One area of significant future cost avoidance is the work TFA has done and continues to do in enhanced sludge washing (see page 15). One of TFA's key current responsibilities is developing R&D for the Salt Processing Project at the Savannah River Site (SRS, see box opposite).

Since many DOE tanks have exceeded their design life and it will be many years before waste is removed, long-term tank integrity is a critical issue for DOE. To provide for real-time corrosion monitoring and reduce personnel exposures, TFA collaborated in the development of two instruments that monitor electrochemical reactions in the tanks. This knowledge enables cost savings through the improved management of corrosion inhibitors (ultimately reducing the amount of high-level waste) and because the monitoring processes are safer and less labor-intensive. In FY 2000, the Hanford Site successfully installed the fourth corrosion probe along with an integrated corrosion monitoring station funded by TFA.

In FY 2000, DOE-Idaho and the Idaho National Engineering and Environmental Laboratory (INEEL), requested TFA's support to address issues related to vitrification (immobilizing high-level waste in glass for safe storage). TFA conducted an independent assessment of the alternatives being considered for treatment of sodium-bearing waste (SBW) and calcine waste as part of INEEL's environmental impact

*A Corrosion Probe is installed to enable tank operators to minimize the amount of corrosion inhibitor added to the waste.*

statement process. INEEL chose direct vitrification as the baseline treatment process for SBW and therefore recommended a baseline change to vitrification, which TFA is supporting through technology development efforts. TFA also provided an expert panel to support roadmapping of SBW. Based on the success of this panel, TFA has been asked to support roadmapping of calcine waste.

Since its inception, TFA has enabled deployment of approximately 100 technologies. TFA technologies helped Oak Ridge close its gunite tanks 12 years ahead of schedule (see page 14). A suite of nine technologies helped the site meet compliance schedules for tank waste retrieval while reducing personnel exposure. As a result of a positive demonstration in the gunite tanks, all the tank projects at Oak Ridge were positively impacted, enabling waste to be moved from older to newer tanks, risk to be reduced, and schedules and costs to be improved.

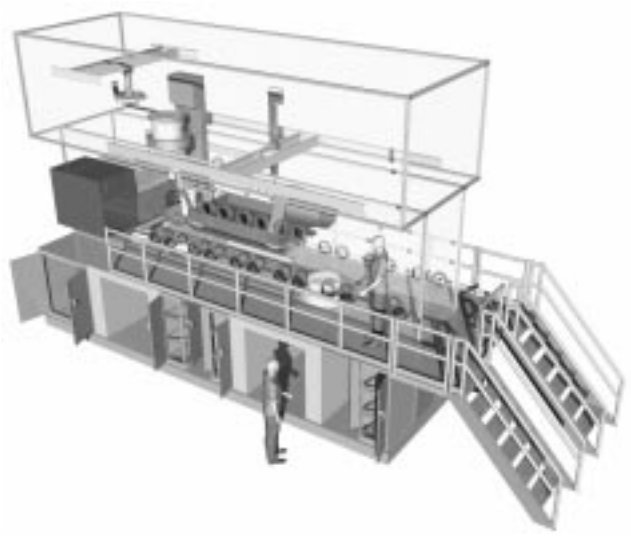
## Salt Processing Project Targets Key Technical Solutions

Of the 35 million gallons of liquid high-level waste (HLW) stored in tanks at SRS, only about 10% is settled, insoluble sludge, which is currently being vitrified in the Defense Waste Processing Facility (DWPF). The rest—salt waste dissolved in the supernatant—contains most of the soluble radioactive element cesium. The salt supernatant removed from the tanks must be processed to remove cesium, strontium-90, and associated ("alpha") radionuclides for immobilization at DWPF. The remaining salt solution—representing the bulk of the volume but less than 0.01% of the radioactivity—can be managed as low-level waste and can be safely disposed of on site. To maintain operations feed to DWPF and to meet tank storage limitations, a new salt waste processing plant must be in full operation by 2010.

In March 2000, DOE asked TFA to manage the R&D portion of the Salt Processing Project (SPP), the project focused on selection, construction, and startup of the new plant. This critical role included review and revision of the technology development roadmaps, development of selection criteria for a preferred cesium-removal technology, and development of a comprehensive R&D program plan for the three candidate cesium-removal technologies, as well as the alpha- and strontium-removal technologies. Major technical accomplishments in FY 2000 include development of alternative alpha- and strontium-removal technologies, improvement of operating parameters for and confidence in the ion exchange cesium-removal process, demonstration of the validity of the solvent extraction cesium removal process, and identification of catalytic decomposition factors associated with the small-tank precipitation cesium-removal process. Participants in the SPP R&D program, funded jointly by OST and the Office of Project Completion, include Savannah River Technology Center, Oak Ridge National Laboratory, Argonne National Laboratory, Sandia National Laboratories, Pacific Northwest National Laboratory, and various universities and commercial vendors.

The **Transuranic and Mixed Waste Focus Area** (TMFA) is the result of connecting the previous Mixed Waste Focus Area with the National Transuranic Program in Carlsbad, N.M. to help meet the technology needs of this national program. TMFA addresses more than 150,000 cubic meters of transuranic (TRU) and mixed low-level waste stored at 36 sites. About 70% is TRU waste destined for disposal in the Waste Isolation Pilot Plant (WIPP). Cleanup will generate over one-half million additional cubic meters of TRU and mixed low-level waste in the next 70 years, more than a third of it in the next 10 years. TMFA is presently addressing or planning to address approximately 140 technology needs identified by the DOE sites for waste management. In FY 2000, sites deployed six TMFA technologies and five were demonstrated. Leading OST's team to develop alternatives to incineration is an important current focus for TMFA (see box).

Phase 1 of HANDSS-55, a remotely operated packaging system, was deployed at SRS in FY 2000. This technology includes components developed by INEEL, SRTC, and Pacific Northwest National Laboratory (PNNL). Many DOE sites have mixed waste temporarily stored in 55-gallon drums that need further treatment or evaluation before preparation for final disposal. This modular system opens 55-gallon drums, provides access to contents for verification or repackaging, enables removal of items that are not compliant with acceptance criteria of the disposal site, and closes drums in preparation for transfer. It offers substantial benefits over the baseline by eliminating hand-sorting of waste, thereby reducing worker exposure.



*When complete, HANDDS-55 will help SRS ship a steady flow of waste acceptable to WIPP.*

Another new technology, the Transuranic Optimized Measurement System, was successfully demonstrated in FY 2000 on simulated wastes at SRS. The system uses an innovative detector to segregate TRU from non-TRU waste, performing analysis in less than 45 minutes. An exciting benefit of this technology is the reclassification of a significant portion of transuranic waste as low-level or mixed low-level waste, resulting in cheaper disposal alternatives than if the waste had to be disposed of at WIPP.

A powdered mercury sorbent, known as SAMMS material and developed by PNNL, was demonstrated this year on mercury-containing organic liquids at the DOE's Mound Facility in Ohio. The material, 5 grams of which has the total surface area of a football field, will be used to separate mercury from wastes containing organic materials. This technology will enable the organic portion of the waste to be prepared for thermal treatment and the volume of secondary waste to be minimized and disposed of as a stable waste form. In FY 2001, SAMMS material will be used to treat 1000 gallons of mercury-contaminated, tritiated oil and additional smaller quantities from other sites, resulting in substantial cost savings.

## Technical Leadership Helps Find Alternatives to Incineration

Public concern about incinerator emissions, the recently mandated Environmental Protection Agency (EPA) requirements to enhance monitoring and treatment of these emissions, and the cost of operations have encouraged DOE to identify, evaluate, and consider implementation of alternatives to incineration. In April 2000, as part of a lawsuit settlement agreement, the Secretary of Energy, with the assistance of the governors of Idaho and Wyoming and input from public interest groups, appointed a Blue Ribbon Panel on Emerging Technological Alternatives to Incineration. The panel's objective was to evaluate and recommend new technological initiatives that DOE could pursue in establishing alternatives to incineration of low-level and transuranic wastes containing polychlorinated biphenyls (PCBs) and hazardous constituents, now stored at INEEL and other DOE sites.

OST and TMFA provided consistent and reliable technical assistance and support throughout the panel's deliberations and report preparation. Based in part on the focus area's six-year history of examining DOE needs to treat waste streams not amenable to incineration, TMFA was able to play a valuable role in helping the panel meet its objective. The panel also benefited from the technical assistance of three independent reviewers and a DOE review team. In December 2000 the panel's report was published and accepted by the Secretary. Panel findings determined that there are promising technological alternatives to incineration but that these alternatives need to be further developed, adapted, and tested with actual mixed waste. The panel offered recommendations for DOE to pursue in planning and developing alternatives that address the issue of disposition of transuranic and mixed low-level waste.

As part of an overall focus on making deployable technologies available for treatment, TMFA will conduct an evaluation of the various alternative technologies against the panel's criteria, sources of waste, various site treatment and disposal needs, and stakeholder concerns and conduct demonstrations of selected technologies at industrial or DOE site facilities. In addition, following the recommendations of the panel, a research, development, demonstration, and deployment plan will be prepared and implemented by TMFA. The plan will describe an accelerated and supplemented effort to develop alternatives in response to the panel's recommendations. The plan will focus on two types of treatment options: robust treatments capable of treating a wide variety of waste compositions and simple, partial treatments capable of removing volatile organic compounds and hazardous organic compounds like PCBs in sufficient amounts to enable shipment of the waste to WIPP or to other sites. The EM program anticipates that at least one alternative technology system for each of these options will be developed, demonstrated, and made readily available for deployment at one or more DOE sites.

***More success stories and contact information appear in the focus area annual reports, available through the OST Web site at http://ost.em.doe.gov. More detailed technical and deployment information on the specific technologies named in this report is also available through the OST Web site. You can search EM's Technology Management System under the "Tools" Button and find individual Innovative Technology Summary Reports categorized by focus area under "Publications."***

# Basic and Applied Research Provides Important Knowledge and Enhances Capabilities

Demonstrations and deployments of improved technologies are more readily counted than the benefits of improved knowledge and understanding of materials and processes. However, even when new knowledge doesn't quickly result in new methods or equipment, it can enable the establishment of—or quantum improvements in—baselines by improving the basis for decision making: regulatory and compliance decisions, remediation strategies, or process selection. It can also improve performance of existing systems. In either case, new knowledge can ultimately avoid costs, enhance safety, and reduce technological risk.

Through the Environmental Management Science Program (EMSP), OST is currently working with 90 universities and 35 national, other governmental, and private laboratories, investing in targeted basic research to generate breakthroughs and innovations that will lead to the cleanup technologies of the future. Recent projects of the EMSP have produced improved technologies for worker safety, tank waste remediation, and remediation of groundwater contaminated with metals and DNAPLs.

In FY 2000, OST awarded nearly $30 million through EMSP to renew 42 research projects addressing the nation's most complex cleanup challenges. To date, EMSP has funded 316 projects, many of which are already having an impact on DOE's and the nation's cleanup efforts.

The results of research directed to developing state-of-the-art personal and environmental exposure assessment for inhaled radionuclides has yielded two new instruments that have been deployed at Fernald. Together these instruments enable measuring the air concentrations of the gas, the airborne particulates, and their particle size. Prior to the development of this instrument, the labor-intensive effort needed and the cost precluded these measurements.

## Unlocking the Mysteries of the Vadose Zone Is Key to Answering Critical Technology Needs

*EMSP research probed how bacteria stabilize metal contamination to optimize inexpensive in situ treatment methods.*

Much of the environmental contamination associated with DOE activities resides in the vadose zone, between the surface and underlying groundwater. Among EM's preeminent scientific needs is a better understanding of the fundamental physical and chemical processes of this region so that scientists and engineers can identify cost-effective options for isolating and removing contaminants before they reach groundwater or the atmosphere. Nearly half of the EMSP projects renewed in FY 2000 focus on solving subsurface contamination problems. *Vadose Zone: Science and Technology Solutions*, a comprehensive reference book on vadose zone science and technology, was also released. This publication, a collaborative effort of SCFA and SRTC, includes the contributions of more than 100 outstanding scientists and engineers. Edited by Drs. Brian Looney, SRTC, and Ronald Falta, Clemson University, this 1,500-page book and companion CD offer insight into the characterization and predictive capabilities of emerging technologies and identify future research and technology needs.

A new antifoaming agent developed by the Illinois Institute of Technology as the result of EMSP-sponsored research is expected to be deployed at SRS's Defense Waste Processing Facility. This material is expected to have broad application in waste tank remediation throughout the DOE complex.

Focus areas and crosscutting programs have transitioned four basic research projects started under EMSP into applied research efforts. These projects include the demonstration of "Laboratory-on-a-Chip" by DDFA, demonstration of a miniature spectrometer for groundwater monitoring by SCFA, and two separate demonstrations of crown ethers for cesium separation at SRS and Oak Ridge National Laboratory by TFA. This latter separation process has also been commercialized and shows great promise of becoming the technology of choice for cesium separation from HLW at SRS.

Nine other projects sponsored by EMSP have also met with commercial success or have been transferred to the focus areas, and field demonstrations are slated for 10 projects related to characterization and monitoring, process improvements, or new remedial methods.

## Research and Development Laboratory Management Stewardship

Secretarial Officers have primary responsibility and accountability for what occurs at every field location and within each program. Designation as a Cognizant Secretarial Officer (CSO) carries with it overall responsibility for activities and programs at a specific set of DOE facilities under the management of a multiprogram field office. This designation also includes responsibility for the institutional health and stewardship at those facilities. The Assistant Secretary for Environmental Management is the CSO for four laboratories: Idaho National Engineering and Environmental Laboratory; Savannah River Technology Center; Environmental Measurements Laboratory; and the Radiological Environmental Sciences Laboratory.

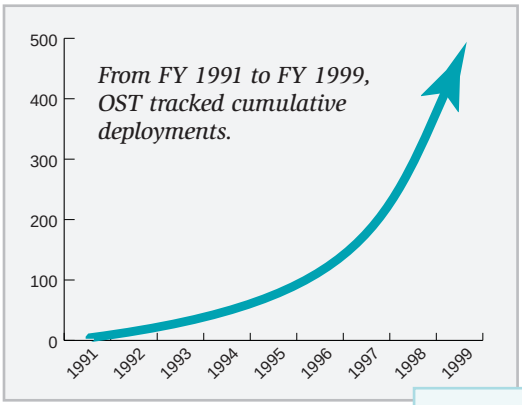
Within that context, and as directed by EM, an OST Laboratory Management Team is providing leadership and oversight to the four laboratories. OST's Laboratory Management Team serves as the steward, or landlord, for key laboratory resources by overseeing their institutional health and assisting with their long-term planning. Programmatic oversight and management is being provided for institutional planning, laboratory-directed research and development, work for others, intellectual property management, technology transfer, technical program reviews, management of laboratory contracts and laboratory performance, and laboratory facilities.

Although laboratory management is a relatively new management responsibility for OST, four major accomplishments were achieved in FY 2000:

- A white paper, prepared by representatives from OST's Laboratory Management Team, operations offices, and laboratories, establishes EM's policy and roles and responsibilities for performing management oversight responsibilities.
- A management plan outlines responsibilities and management processes for CSO functions.
- Baseline reports provide information on the scientific and technical core R&D capabilities and institutional information for each laboratory.
- On-site reviews were conducted at INEEL and SRTC and laboratory-specific institutional plans prepared.

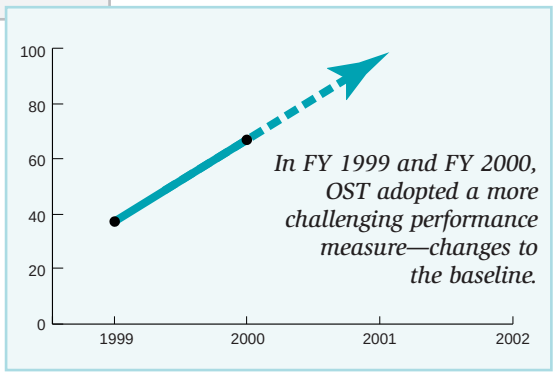
# Innovative Technical Solutions Are Achieving Multiple Deployments and Redefining Baselines

OST's investment in innovative technologies is returning results for EM. One of every five R&D projects has resulted in a viable, deployed technology, an overall success rate higher than that of most R&D organizations.



*From FY 1991 to FY 1999, OST tracked cumulative deployments.*

In the past, OST tracked deployment progress by counting each use, or deployment, of innovative technology. By FY 1999, there were 475 deployments, with 173 in FY 1999 alone. Having achieved the goal of increasing innovative technology deployment, EM instituted more challenging performance targets by measuring the first-time deployment in a cleanup project and changes in the baseline—instances where the innovative technology replaces the traditional technology.



*In FY 1999 and FY 2000, OST adopted a more challenging performance measure—changes to the baseline.*

In FY 2000, innovative technologies were deployed 210 times in 74 EM cleanup projects. These innovative technologies made remediation processes faster, safer, and cheaper, and in some cases, enabled cleanup of otherwise unmanageable contamination. Of these deployments, 74 represent new baselines for various EM projects, such as the following:

- At Idaho and Savannah River, ResonantSonic Drilling replaced conventional drilling methods, which required water or mud for lubrication and removal of cuttings. Eliminating these secondary wastes reduced the risk of exposing drill operators to hazardous materials.
- Active remediation systems for removing carbon tetrachloride from the vadose zone eventually reach a point where costs per units of contamination removed begin climbing rapidly. At Hanford, Passive Soil Vapor Extraction, which uses naturally induced pressure gradients to drive vapor to the surface for treatment, is now the method of choice to continue the remediation and reduce groundwater contamination.
- DOE must characterize radiological contamination inside piping systems before pipes can be remediated, recycled, or disposed. At SRS, the Pipe Explorer system was used to characterize radiological contamination inside piping systems inaccessible with existing technology.
- Advanced Tensiometers were used at INEEL to provide accurate data on seasonal movement of groundwater through waste storage and disposal sites. Unlike conventional tensiometers, which use mechanical pressure gauges, the Advanced Tensiometer can be deployed at almost any depth in the vadose zone to help monitor contaminant transport.
- Purge Water Management System is a closed-loop, noncontact system used to return purge water to the originating aquifer after a sampling event without significantly altering the water quality. It does not require any downhole modification and adapts easily to existing wells. This innovative method for handling the purge water generated during sampling of monitoring wells circumvents the need to containerize and transport purge water to treatment/disposal facilities, therefore minimizing waste, eliminating unnecessary handling of purge water by site workers, and reducing costs. This system is now the baseline at SRS.

# Accelerated Site Technology Deployment Projects Leverage OST Investments

OST's Accelerated Site Technology Deployment has proven its value by stimulating 73 deployments at multiple sites in FY 1998 and 1999 and another 58 in FY 2000. To further promote timely multisite deployments, the program now requires participating sites to fund half of the deployment costs, complete projects within two years, and work with other sites to secure at least two subsequent deployments. With more than 280 deployments already planned, ASTD anticipates near-term multiple site deployments will rise dramatically.

## Technologies that Treat Subsurface Contamination in Place Are Reducing Costs and Enhancing Safety

Remediating subsurface contamination through baseline pump-and-treat methods can take decades and still not remove all contamination. These methods are also expensive and pose risk to workers and environment. Passive Reactive Barriers (PRBs) protect surface water quality and significantly reduce costs and risk by treating contaminant plumes underground and generating less waste material for disposal. PRBs have been installed at Oak Ridge and Rocky Flats, as well as non-DOE sites. The two PRBs currently operating at Rocky Flats are cooperative ventures of the site, the Rocky Flats Field Office, and OST, with partial funding from ASTD.


*Current Passive Reactive Barriers are projected to cut life-cycle costs by more than $100 million.*

## In Situ Gamma Spectrometry Speeds Confirmation of Cleanup Success

The Fernald Environmental Management Project is on a fast track to complete final cleanup. In FY 2000, the Environmental Measurements Laboratory (EML), along with Argonne National Laboratory and INEEL, applied in situ gamma spectrometry for post-cleanup precertification in an ASTD project. Large areas of land outside the production area at Fernald have now been certified on a near real-time basis as meeting final remediation levels. This technology has become an integral part of Fernald's soil characterization efforts and is helping the site meet its stringent schedule, saving in excess of $15 million to date and about $19 million in additional, anticipated cost savings over the next five years.

*Nearly 1,400 drums of Oak Ridge waste were compacted and encased in only 80 sleeves for safe transport and economical storage.*

## Compacted Waste Facilitates Transport and Conserves Storage Space

Prevailing macroencapsulation approaches are bulky, with correspondingly high transportation and storage costs. An ASTD project, sponsored by TMFA and managed by Florida International University, combined waste compaction and macroencapsulation to create a safe, volume-reduced, and transportable waste form. Mixed waste debris from Oak Ridge was prepared for shipment and storage at Envirocare in Utah. The process involved compaction of the waste drums, loading them into overpack containers, and encapsulating the overpacks in sleeves. The project achieved overall volume reduction of greater than 20%—even with the overpacking—occupying volume less than half that required by conventional processes. This reduction translates to big savings on transportation and storage.

***Innovative technologies that solve specific EM cleanup problems are rapidly emerging from the development and demonstration pipeline to be deployed—often many times and at multiple sites***

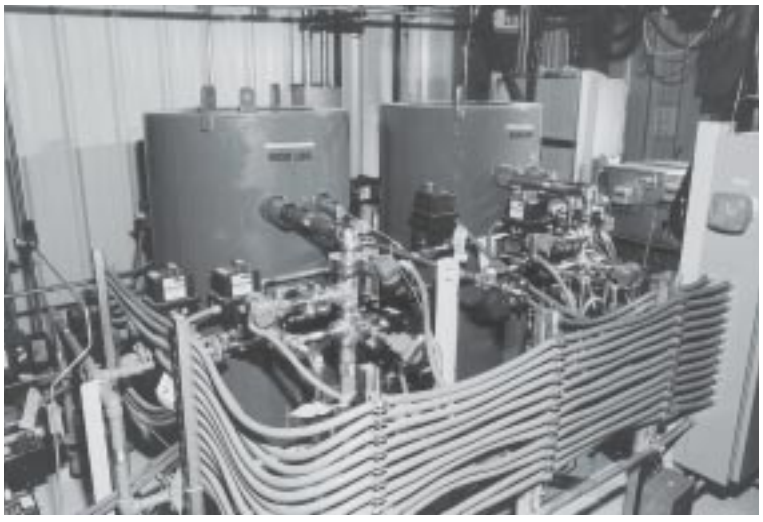
# EM's Investments in Science and Technology Are Paying Off in Life-Cycle Cost Reductions

In just over 10 years OST has spent about $3 billion (less than 3% of EM's $57 billion total budget), but that investment in science and technology has saved more than $9 billion. Technologies now exist that are projected to save far more. Some of the larger benefits of these have already been documented:

- A $350 million reduction in the cost of the cleanup of the Gunite and Associated Tanks at Oak Ridge using a suite of new tank waste and retrieval technologies and cesium removal
- A $50–100 million reduction in the cost of the cleanup at Fernald using a groundwater reinjection system
- A $100 million reduction in the cost of groundwater remediation using PRBs at Rocky Flats and Monticello (see page 13)
- A $5 billion reduction in the cost of HLW treatment at Hanford by advances in the ability to remove contaminants from highly radioactive sludge (see opposite)

## Teamed Technologies Cut Waste Volume and Treatment Costs at Oak Ridge—Gunite and Associated Tank Retrieval Completed

Cesium-contaminated tank waste must be treated as HLW, but treating all DOE tank waste as HLW would be cost-prohibitive. The Cesium Removal System deployed at Oak Ridge's Melton Valley Storage Tanks (MVSTs) is a modular, transportable ion-exchange system using crystalline silicotitanate (CST) as the sorbent. Loaded CST is disposed of as HLW, but the filtered liquid is reduced in volume 25% by the Out-of-Tank Evaporator and treated much less expensively as low-activity waste. Baseline methods of disposing of the MVST waste would have cost more than $70 million. These technologies will reduce that cost to $30 million and require less storage space.



*The Cesium Removal System makes most tank waste amenable to cheaper treatment options.*

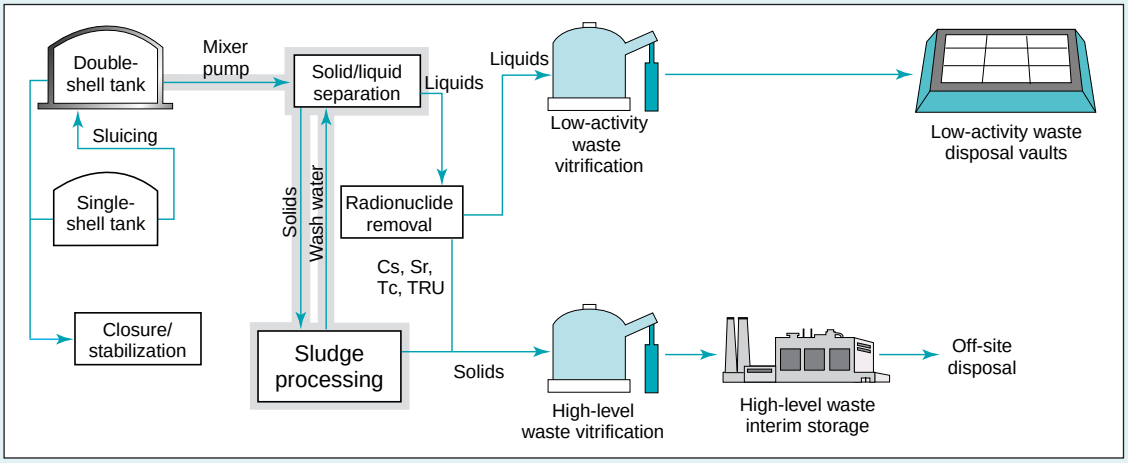
Residual sludge at the bottom of the Oak Ridge National Laboratory Gunite and Associated Tanks hindered closure activities. TFA and its partners, including the Robotics Technology Development Program, worked with users to develop a suite of technologies to meet compliance schedules for tank waste retrieval while filling technology gaps and reducing personnel exposure. Completion of retrieval operations was a significant site cleanup milestone, and results provide valuable information and lessons learned for other DOE tank sites in evaluating retrieval options and planning future retrieval projects.

## Groundwater Reinjection Is Avoiding Costs by Cutting the Schedule at Fernald

Over the years, uranium from Fernald's processing plants contaminated a small portion of the Great Miami Aquifer, one of the largest sources of drinking water in the nation. Reducing the level of uranium in the groundwater to the health-protective concentration limit set by EPA is a primary goal of the Fernald Environmental Management Project. By accelerating the aquifer remediation, groundwater reinjection will help cut costs by $50–100 million. Through the use of this and other innovative technologies, Fernald has projected a reduction in cleanup schedules by 17 years and a savings of $3 billion in remediation costs for the site.

# Enhanced Sludge Washing Cuts Baseline Costs and Improves Worker Safety

Underground storage tanks on DOE sites contain approximately 90 million gallons of highly radioactive wastes. Removing these tanks from service requires that wastes be removed, immobilized, and prepared for permanent disposal. A large percentage of tank wastes include sludges with various chemical and physical properties that have collected at the bottom of the tank over time. DOE's preferred method for safely immobilizing tank sludges is vitrification, but certain chemicals and elements in the tank sludges can complicate the vitrification process and add to the volume of highly radioactive glass, increasing the costs for waste treatment and disposal. Costs per unit volume for vitrifying and disposing of highly radioactive wastes are much greater than those for treating and disposing of less radioactive wastes.




*Enhanced Sludge Washing has an immense effect on tank waste remediation costs by enabling vitrified forms to contain higher concentrations of waste.*

Enhanced Sludge Washing (ESW) uses a concentrated hydroxide solution to remove from tank sludges the soluble nonradioactive components—such as aluminum, chromium and phosphorus—that require increased glass volume. The wash liquid is decanted, further treated to reduce the concentration of radionuclides, immobilized as low-activity waste, and sent to on-site disposal. Most of the radionuclides remain in the sludges, which are vitrified and prepared for off-site disposal in a geologic repository. The difference is that, because the glass can be "loaded" with higher concentrations of waste, far fewer waste forms require processing, transport, and storage. This scenario not only dramatically reduces costs but also enhances worker safety.

DOE determined that ESW for pretreatment of Hanford tank sludges would produce an acceptable number of glass canisters. With partners from Oak Ridge National Laboratory, Pacific Northwest National Laboratory, and Sandia National Laboratories, TFA has sponsored process tests to determine how tank wastes respond chemically and physically during ESW to guide sites in selecting the best processing conditions. TFA funded tests on sludge samples so that process engineers could develop full-scale process flow sheets for Hanford waste types. With the expectation that ESW will reduce by 60% the volume of Hanford tank sludges requiring expensive treatment and off-site disposal, an estimated cost avoidance of almost $5 billion has been included in the Hanford baseline.

***OST is answering today's needs—making EM cleanup possible, affordable, and safe—and zeroing in on the EM needs of the future***

# EM Is Preparing for the Age after Remediation

Though cleanup will continue at a number of major DOE sites after 2006, over 60 sites are expected to have been remediated by then as far as technologically and economically feasible. However, residual contamination at many sites will require attention for the foreseeable future to protect human health and the environment. Long-term stewardship (LTS) requires the use of both institutional controls and engineering controls to be successful.

LTS activities are subject to multiple and various legal requirements, and a number of issues remain unresolved. Cleanup decisions being made today will have a huge impact on our future ability to be good stewards. Early in FY 2000, the Assistant Secretary for EM expanded OST's mission to include responsibility for LTS policy and planning.

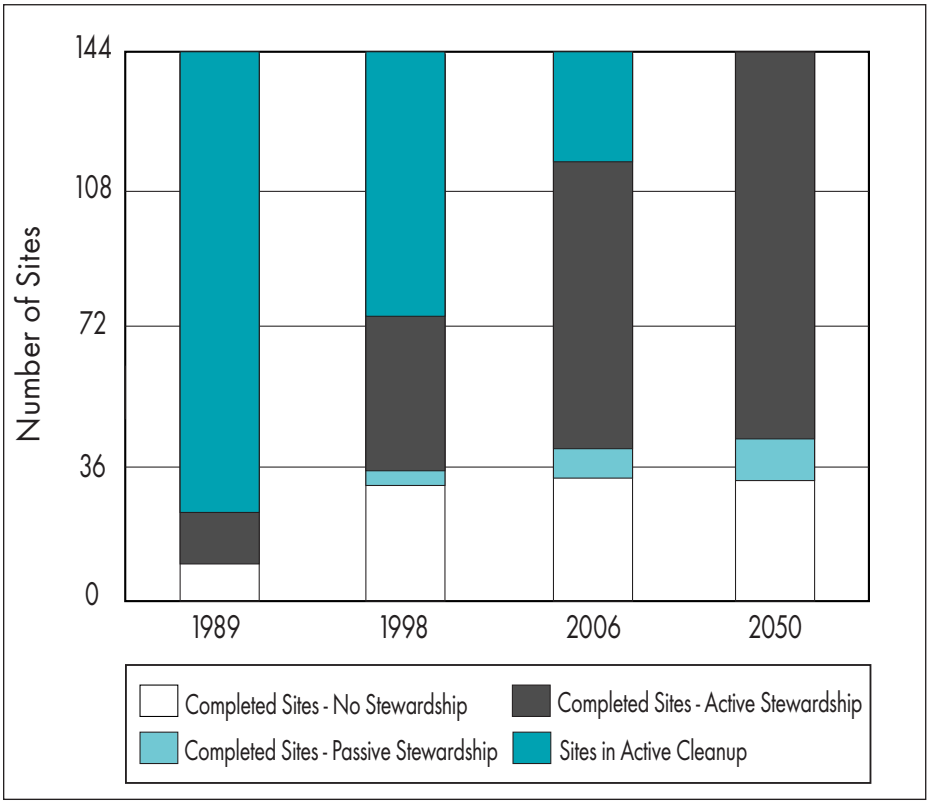
Early estimates for LTS costs exceed $100 million per year indefinitely, and risks from exposure after currently planned remediation vary. Future re-remediation, based on new technologies, could be an effective way of lowering risk and overall LTS costs. A challenge facing the Office of Long-Term Stewardship (OLTS) is similar to that facing the rest of EM: we need technologies that are more effective, permanent, and affordable.

Particular stewardship technology needs include

- understanding fate and transport,
- materials durability,
- surveillance and monitoring,
- information management, and
- energy sources.

While addressing these needs, OLTS is working to balance regulatory requirements with the long-term impacts of expediting cleanup to meet remediation commitments and to help stakeholders and regulators understand the long-term effects of the decisions we make today.

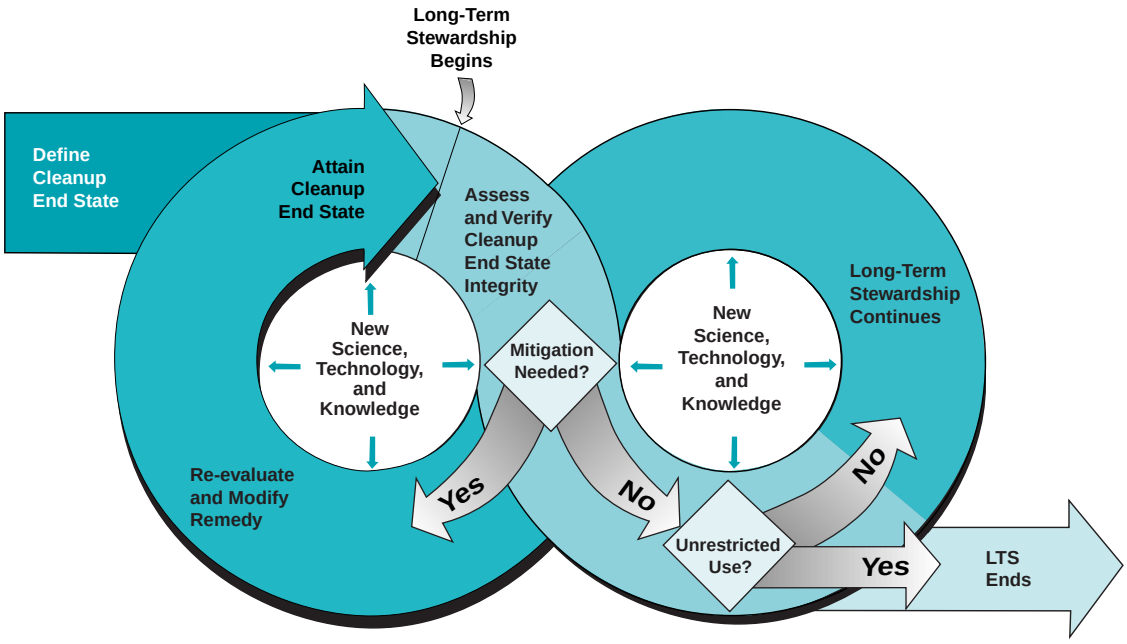
In FY 2000, OLTS developed a report on DOE sites or portions thereof that expect to complete environmental restoration, waste management, and facility stabilization activities by 2006. *Report to Congress: Long-Term Stewardship* helps establish a baseline of LTS scope, cost, and schedule and identifies key steps for improving management and accountability to better understand the scope of LTS, incorporate LTS elements into life-cycle planning, and coordinate requirements and activities with stakeholders.




*As sites are remediated to the extent feasible, they are moved into stewardship.*

OLTS also drafted a *National Long-Term Stewardship Study* to comply with terms of a settlement agreement between DOE, the Natural Resources Defense Council, and other plaintiffs.

Both reports are available through the online LTS information center at http://www.em.doe.gov/lts.




*Planning for long-term stewardship is a dynamic process requiring science and technology in every stage.*

## Innovative Technologies: Safety Included

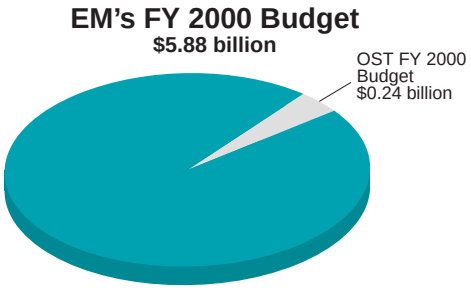
In FY 2000, the Environmental Management Advisory Board (EMAB) found that "the OST Program addresses occupational safety and health more comprehensively than other federal agencies with development programs in the remediation technology sector." EMAB recommended several actions by which OST's performance in this area could be further improved. Working collaboratively with EM's Office of Safety, Health, and Security, OST began development of a new safety and health policy to implement the recommendations.

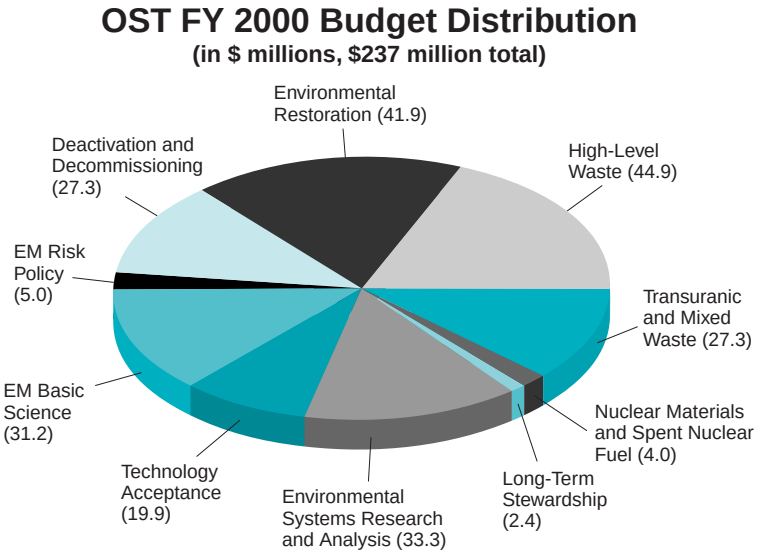
In this policy, OST formally commits to ensuring that safety is included at the earliest stages of innovative technology design and that safety data is collected and analyzed during demonstrations. The active involvement of everyone from technology developers to workers operating equipment during the demonstration phase will be needed to assess potential hazards and to suggest mitigating actions. Considering safety early and often ensures that innovative technologies will be safer to use and will better achieve the positive impacts needed to improve cleanup schedules and expenses.

To help reduce regulatory barriers to the deployment of innovative technologies, OST helps fund the **Interstate Technology and Regulatory Cooperation Working Group**. This group brings regulatory agencies and technology developers, vendors, and users together to increase the collective confidence of the environmental community for using innovative technologies.

ITRC has technical teams specifically focused on issues of concern to DOE. In FY 2000, ITRC's DNAPLs Team began participating in the Interagency DNAPL Consortium (see page 4). The Radionuclides Team met several times with staff from OST's Long-Term Stewardship Program and began work on a new document focused on the various technologies and regulatory mechanisms DOE is considering to implement long-term stewardship at DOE sites. In FY 2001, a new team will be working collaboratively with DOE to ensure early regulator involvement in technology demonstrations.

# Responsible Investments in EM Problem Areas



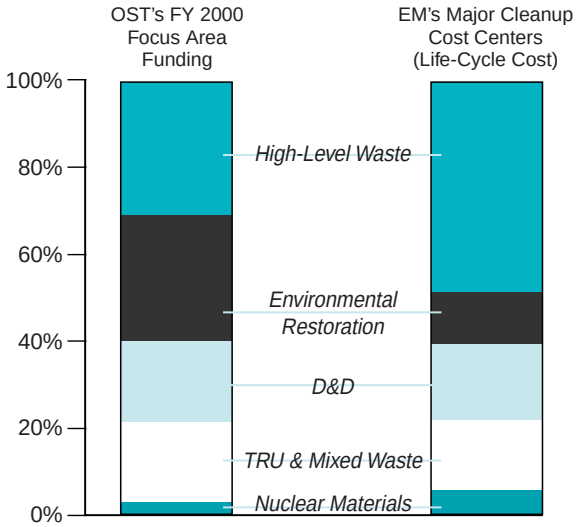




With just over 4% of EM's FY 2000 budget, OST funded a wide range of science and technology needed to support the environmental management and restoration of DOE's sites. Investments in basic science and risk policy uncover new solutions and help provide fundamental understanding to improve worker safety and health. OST investments in technology demonstration and deployment benefit the areas of high-level waste, transuranic and mixed waste, nuclear material, environmental remediation (subsurface issues), and deactivation and decommissioning. To help facilitate the process of technologies being incorporated into cleanup plans, OST also invests in technology acceptance and systems research and analysis. Finally, OST invests in long-term stewardship to help address future needs in the areas of long-term monitoring and surveillance after cleanup is complete.

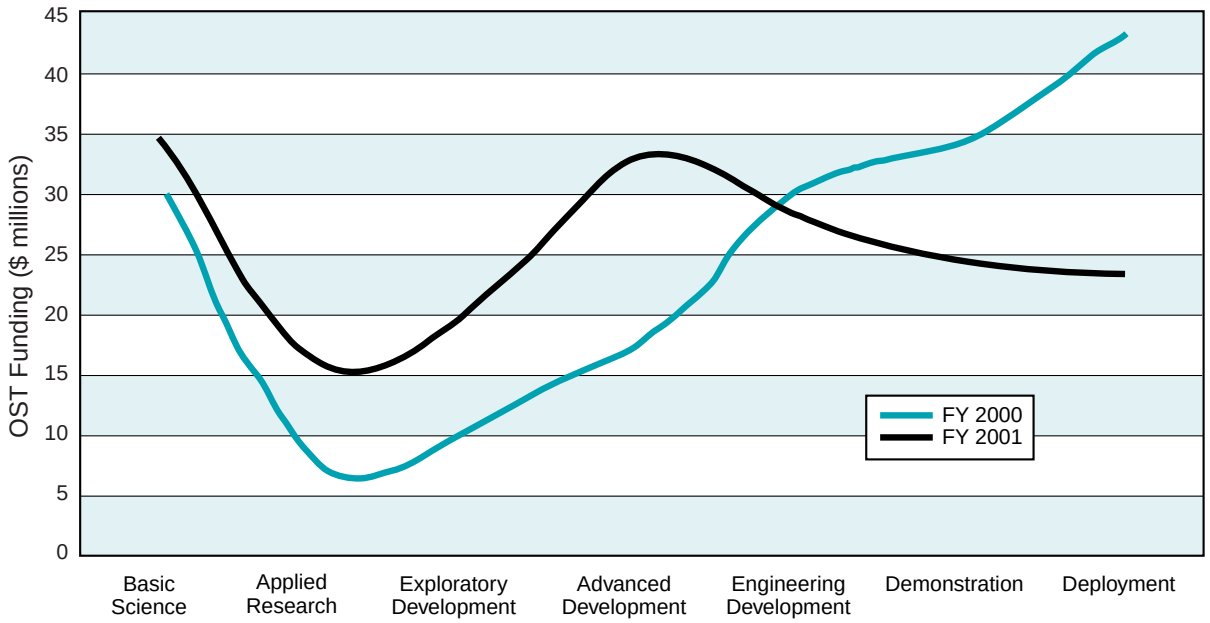
OST recognizes that identifying and developing technologies to solve problems requires cooperation and creativity from multiple sources. OST funding and active cooperation with laboratories, universities, and the private sector support basic and applied research and bring existing technologies into EM. Through FY 2000, OST's Environmental Management Science Program has funded $221 million for collaborative efforts with 90 universities, 13 DOE laboratories and 22 other governmental labs, 39 states, the District of Columbia, Canada, Australia, the Czech Republic, the United Kingdom, and Russia.

OST works to match its investments to EM's priorities. Life-cycle cost analysis helps indicate where investments in science and technology should be focused to help reduce the likely high-cost areas today and in the future. More than two thirds of the EM life-cycle cost estimate is expected to be incurred after 2006. The single greatest category of these costs is attributable to managing high-level waste at EM's most challenging cleanup sites—INEEL, Hanford, and SRS. Accordingly, OST focuses a significant portion of its budget in that area.

Since 1998, life-cycle cost estimates for site cleanup and closure have increased by approximately $17 billion (11%), and experience indicates these costs will continue to rise. Over time, the total number of technology needs identified by DOE sites has also significantly increased. Of those needs, the number that are considered to have the highest priority has increased at a faster pace. To reduce life-cycle costs and successfully address EM's long-term cleanup problems, continued investments in science and technology are critical.




*OST's focus area funding reflects EM's life-cycle costs.*




*OST balances its funding across the technology maturation process.*

OST's investments must address all steps in the technology development process, from basic science through deployment. In FY 2000, while still emphasizing basic science and deployment, OST began shifting more resources into development to set the stage for future demonstrations and deployments. This more balanced approach will help OST continue to give problem holders the science and technology solutions they need, when they need them.

**Additional information about OST programs and technologies is available on the Internet:**

**Office of Science and Technology • http://ost.em.doe.gov**

- Program Information
- Technology Management System
  - Detailed on-line information on all OST technologies
- Publications
  - Innovative technology summary reports
  - Focus area annual reports
  - Success stories
  - Deployment information

**Office of Long-Term Stewardship • http://lts.apps.em.doe.gov**

**Focus Areas**

- Deactivation and Decommissioning • http://www.netl.doe.gov/dd
- Nuclear Materials • http://emi-web.inel.gov/nmfa/index.htm
- Subsurface Contaminants • http://www.envnet.org/scfa
- Tanks • http://www.pnl.gov/tfa
- Transuranic and Mixed Waste • http://wastenot.inel.gov/mwfa

**Environmental Management Science Program • http://emsp.em.doe.gov**

**Office of Environmental Management • http://www.em.doe.gov**